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## Shear Stress

### WORLD OF PHYSICS

- Astrophysics
- Electromagnetism
- Experimental Physics
- Fluid Mechanics
- History and Terminology
- Mechanics
- Modern Physics
- Optics
- States of Matter
- Thermodynamics
- Units & Dimensional Analysis
- Wave Motion

### ALPHABETICAL INDEX ➤

- ABOUT THIS SITE
- FAQs
- WHAT'S NEW
- RANDOM ENTRY
- BE A CONTRIBUTOR
- SIGN THE GUESTBOOK
- EMAIL COMMENTS

### ERIC'S OTHER SITES ➤

Shear stress  $\sigma$  is quantity with units of pressure that is related to the strain rate experienced by a fluid by

$$\sigma \equiv \eta[\text{strain rate}], \quad (1)$$

where  $\eta$  is the dynamic viscosity. Writing out the strain rate then gives

$$\sigma = \eta \dot{\epsilon} = \eta \frac{1}{l} \frac{dl}{dt}. \quad (2)$$

The shear stress thus expressed the tendency of a fluid to be "pulled apart" (sheared) by a differential force, with  $\eta$  acting as a resistance to the shear.

There is a shear stress on a fluid having a velocity  $u$  on the upper layer but which is constrained to be zero at a lower boundary at a distance  $d$  below the upper surface. For a Newtonian fluid,

$$\frac{du}{dy} = \frac{1}{l} \frac{dl}{dt} = \frac{u}{l}. \quad (3)$$

But the gradient from bottom to top is

$$\frac{du}{dy} = \frac{u}{d}, \quad (4)$$

so

$$l = d \quad (5)$$

and the shear stress is simply given in this case by

$$\sigma = \eta \frac{du}{dy} = \eta \frac{1}{l} \frac{dl}{dt} = \eta \frac{v}{l} = \eta \frac{v}{d}. \quad (6)$$

**SEE ALSO:** Dynamic Viscosity, Shear, Strain Rate, Stress

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